EUR 8534 EN

Commission of the European Communities

Multiannual Programme
of the Joint Research Centre
1980-1983

1982
ANNUAL STATUS REPORT
OPERATION OF THE HIGH FLUX REACTOR

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OPERATION OF THE HIGH FLUX REACTOR

Abstract

The high flux materials testing reactor has been operated in 1982 within a few percent of the pre-set schedule, attaining 73% overall availability.
Its utilization reached another record figure in 20 years: 81% without, 92% with, the low enrichment test elements irradiated during the year.

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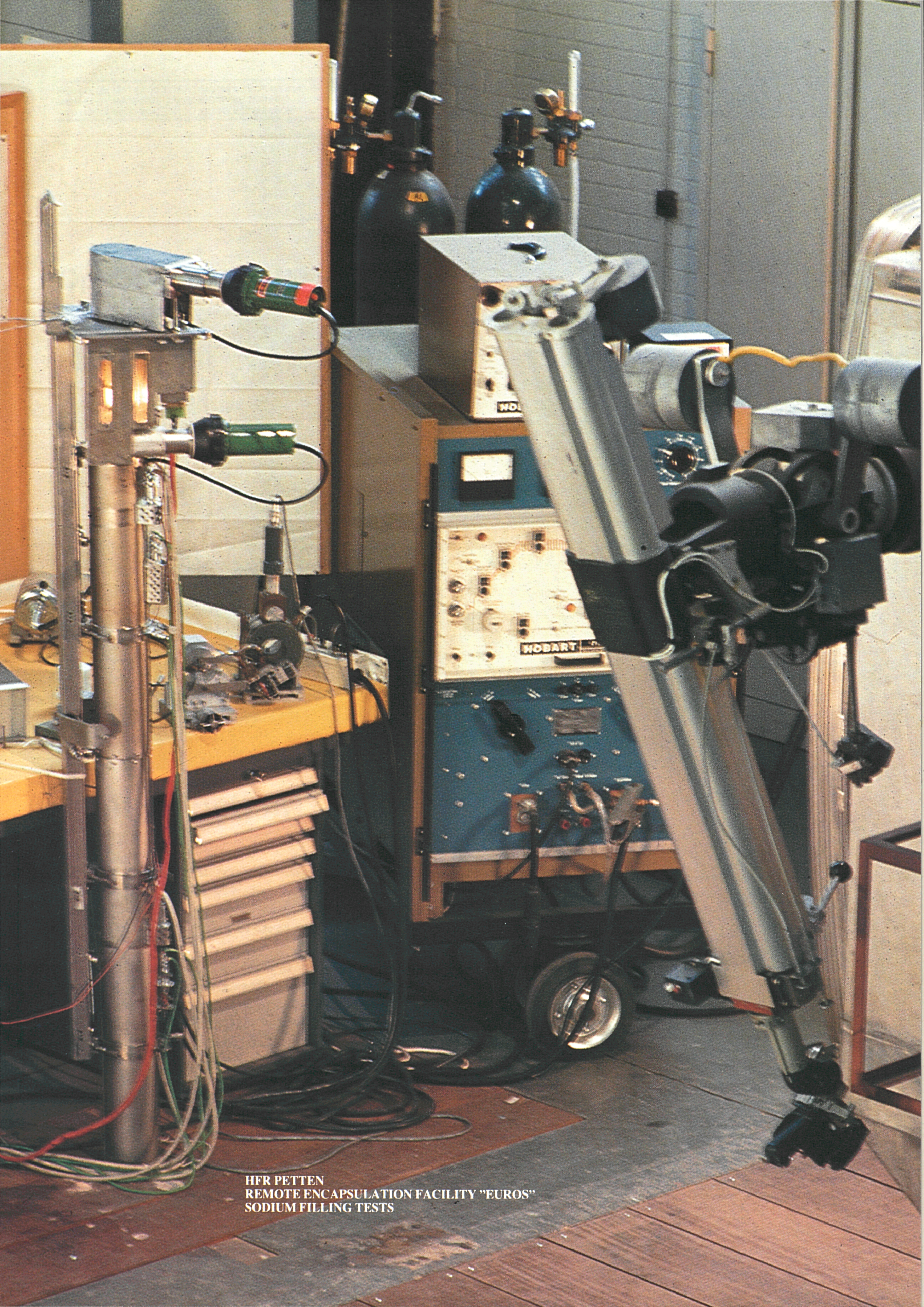

HFR PETTEN
REMOTE ENCAPSULATION FACILITY "EUROS"
SODIUM FILLING TESTS

Operation of the HFR reactor 1982

Research Staff — **41 persons**

Budget "Operation of the HFR"	**14.0 Mio ECU**
Manufacture of replacement vessel	**0.6 (commitment credits)**
Use of HFR by other JRC programmes	**0.8**
Use by commercial clients	**0.2**
Total	**15.6**

Projects

Unlike most of the other JRC Programmes, "HFR Operation" is not formally subdivided into individual projects. For the sake of the Programme Progress Reports, however, three projects are defined:

1. **HFR Operation and Maintenance**
2. **Reactor Utilization**
3. **General Activities**

On a lower level of subdivision, the term "project" appears again when referring to irradiation projects and individual supporting activities.

Programme Manager:
P. von der HARDT

1 Introduction

As one of the most powerful materials testing reactors in Europe, the High Flux Reactor at Petten supports research and development in a number of areas, e.g.

- the development of nuclear fission energy, especially under safety aspects
- irradiation behaviour studies of potential materials to be used in controlled thermonuclear fusion devices
- fundamental research with neutron beams, in particular solid state and nuclear structure physics
- the production of radioisotopes for medical, industrial, and agricultural purposes
- neutron activation analysis for geological and environmental studies.

The reactor, its experimental facilities, and the ancillary services have been continuously upgraded with the goal of maintaining a high degree of reliability and of responding to the permanently changing requirements of scientific/technical research.

As a result, plant and equipment have demonstrated a consistent availability, near to 100% of scheduled operating time. Simultaneously, the reactor occupation has been on a very high level, i.e. an average of 71% in 1980
78% in 1981
81% in 1982 *)

confirming that reactor, facilities, and services are in a position to handle a large experimental work volume on schedule.

*) The 1982 occupation, calculated with low enrichment test fuel elements as irradiation experiments, actually exceeded 90%.

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2 Objectives

The programme objectives are

1. to operate the reactor in a predictable and reliable way
2. to cooperate with different research teams for the scientific, technical, and administrative definition of reactor utilization projects
3. to direct and manage such projects
4. to develop new methods and equipment for future tasks
5. to maintain international contacts and coordination through meetings, symposia, and publications.

HFR Petten

Upgrading and development 1966-1982

- **Power increases 20 to 30, 30 to 45 MW**
- **Introduction of burnable poison fuel (1973/74)**
- **Several core configuration changes**
- **Complete replacement of reactor and general purpose experimental instrumentation**
- **New in-tank experiment penetrations (1976)**
- **Several improvements on major plant systems**
- **In-house computer code developments**
- **New reactor and experiment data loggers (1980/81)**
- **New dismantling cell transfer system (1980/81)**
- **Second (beam tube) neutron radiography facility (1981)**
- **Modification of the reactor building entrance/exit area (1981/82)**
- **Enlarged computing facilities (1981/82)**

Future developments

- **Replacement of the reactor vessel (1983)**
- **Development of redundant shut-down systems (1983/84)**
- **Replacement of primary heat exchangers (1984/86)**
- **Medium activity laboratory (1988/89)**
- **Neutron beam quality improvements (1984/85)**
- **New pool neutron radiography camera, image analyser (1985)**
- **Studies on complete reactor instrumentation and control room replacement**
- **Studies for a power increase to 60 MW**

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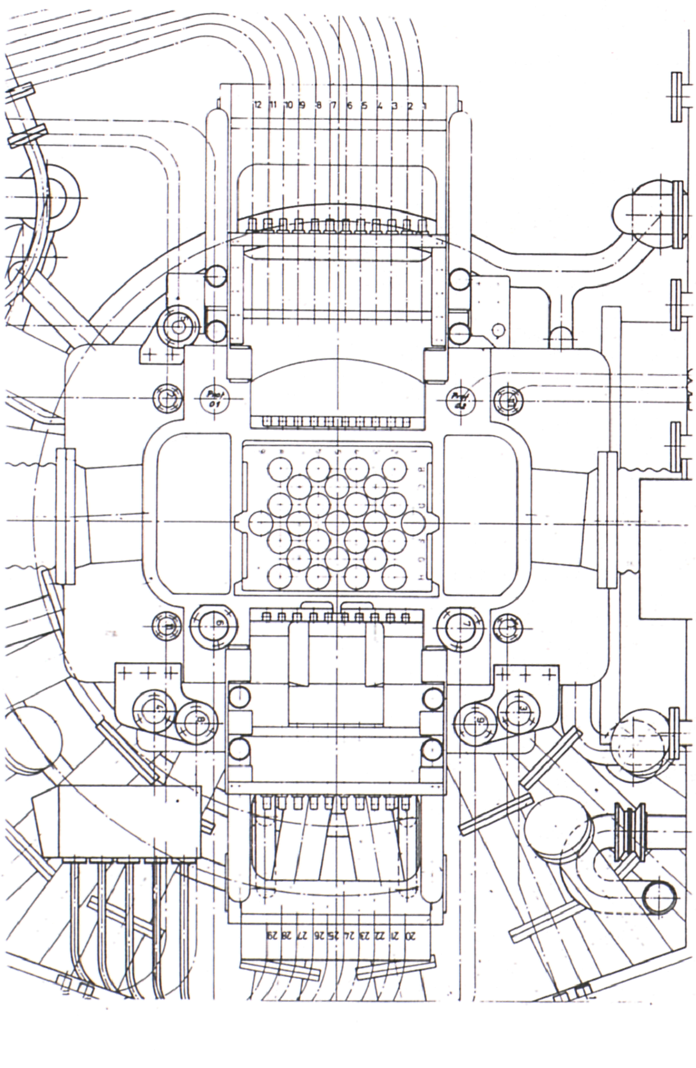
3 Results

3.1 Facilities and Services

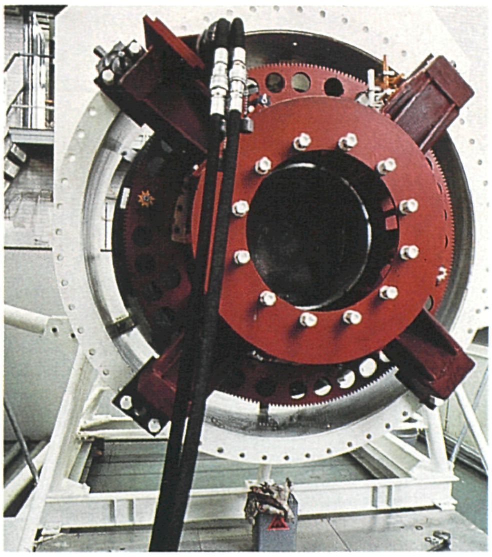
3.1.1 Reactor

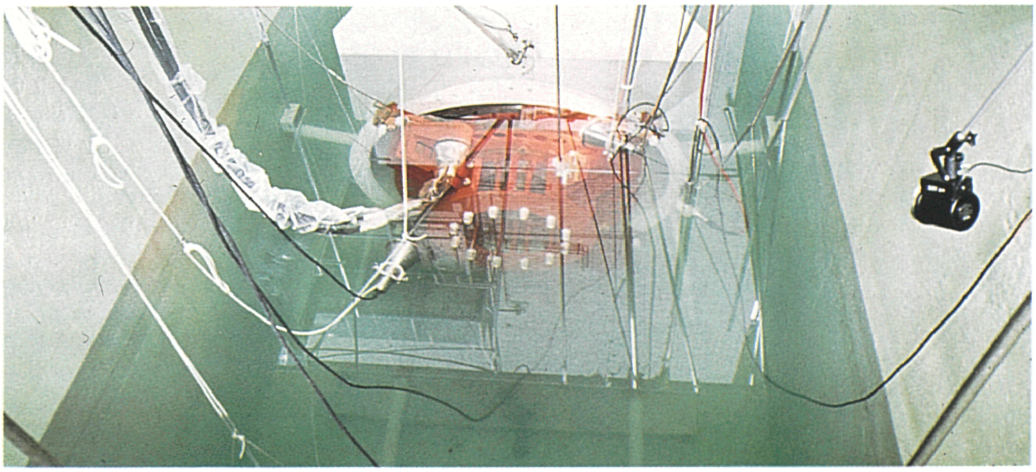
Reactor operation continued in 1982 at 45 MW, to normal schedule. Routine maintenance including inspection, repair and replacement took place during the winter and summer outages. The entrance/exit areas inside the containment building (3rd floor) and at the air lock have been modified for improved radiological safety. The major off-routine activities, however, concerned the preparations for the 1983 reactor vessel replacement, consisting mainly of

- final design of all structure surrounding the new vessel in its pool,
- supply design forged and rolled components, and first machining of the vessel components
- development and tests of apparatus for the remote disassembly and cutting of the present vessel.

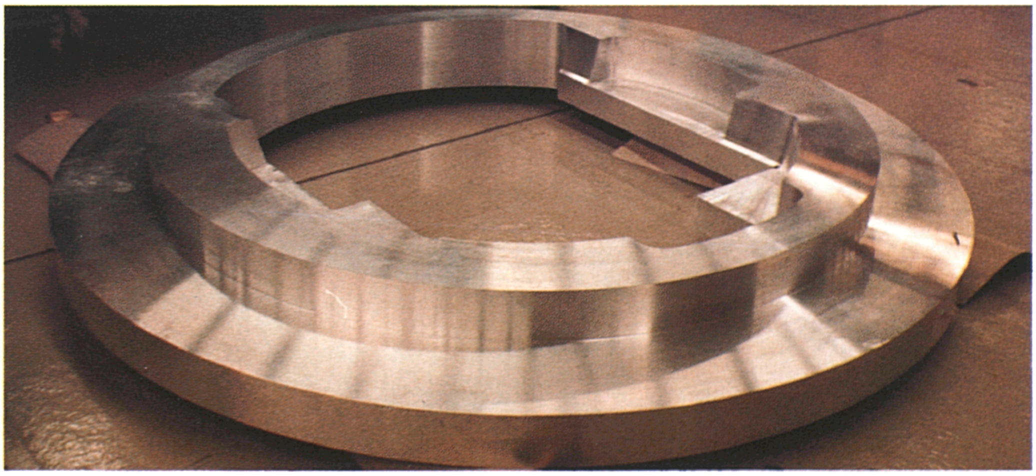


HFR PETTEN
New reactor vessel
View onto the reactor and surrounding pool equipment





HFR PETTEN
Reactor vessel replacement
Remotely operated tool for underwater cutting of the present thermal column front end
First mock-up tests



HFR PETTEN
Replacement vessel manufacture

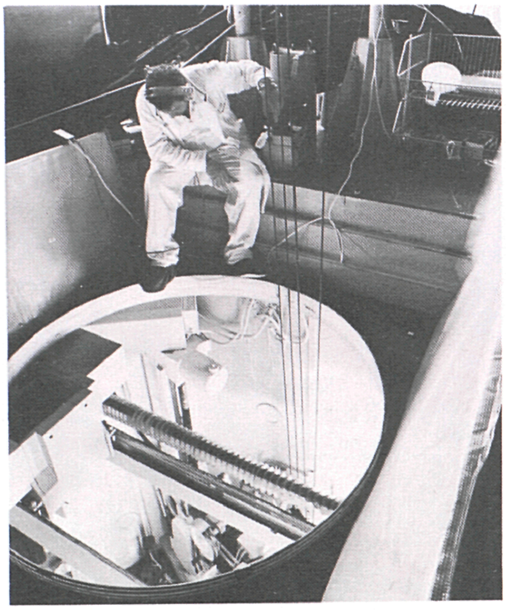
Lower bulk head main flange

3.1.2 Hot cells

Hot cell facilities available for the HFR programme comprise:

- the Dismantling (DM) cell on top of the reactor pool,
- a series of lead cells,
- a series of lead and concrete cells in the adjacent Dutch research establishment ECN.

In 1982 the DM cell has been completely overhauled and the lead cells have been equipped for dimensional measurement of in-pile steel creep samples. Work has moreover been continued on the large remote encapsulation facility "EUROS" which will be installed into one of the lead cells of JRC Petten.

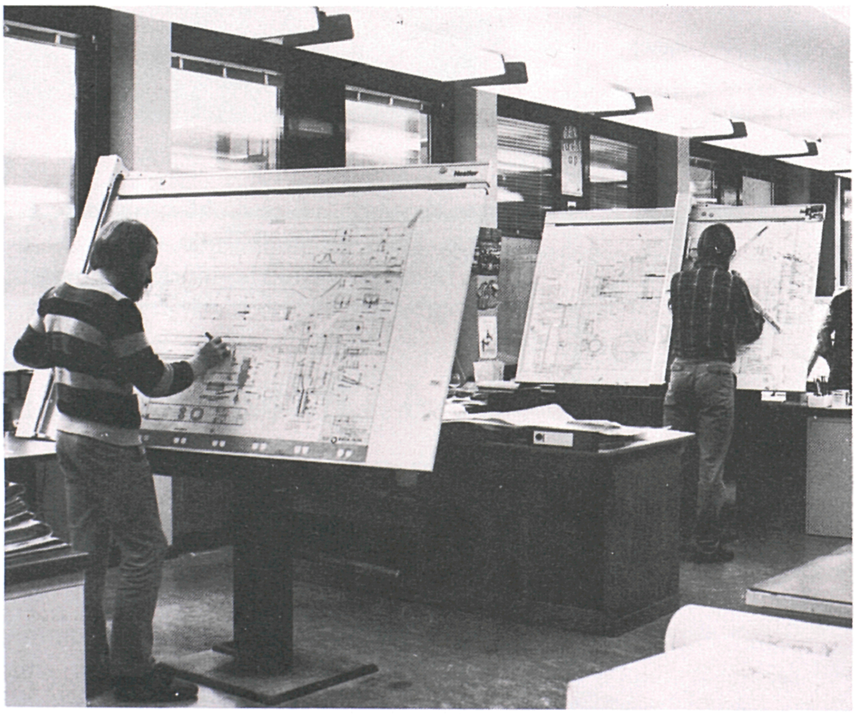


HOT CELLS
Overhauling of the DM Cell

3.1.3 Ancillary services

Users of the reactor find access to the necessary ancillary services, ranging from drawing office, workshop, and several computer installations to a full spectrum of post-irradiation facilities (see above).
New developments in 1982 had to be reduced in favour of preparations for the reactor vessel replacement.

The accurate determination of HFR nuclear characteristics which is essential for the interpretation of many irradiation experiments has been pursued with the evaluation of the neutron metrology program "FLUX 81". A special aspect of this program was the application on large scale of mock-up TRIO and REFA assemblies and the use of GAMIN, tungsten and sapphire damage detectors, as developed in France and the United Kingdom. The mock-up assemblies constitute a much better simulation copy of the experiments



ANCILLARY SERVICES
Drawing office

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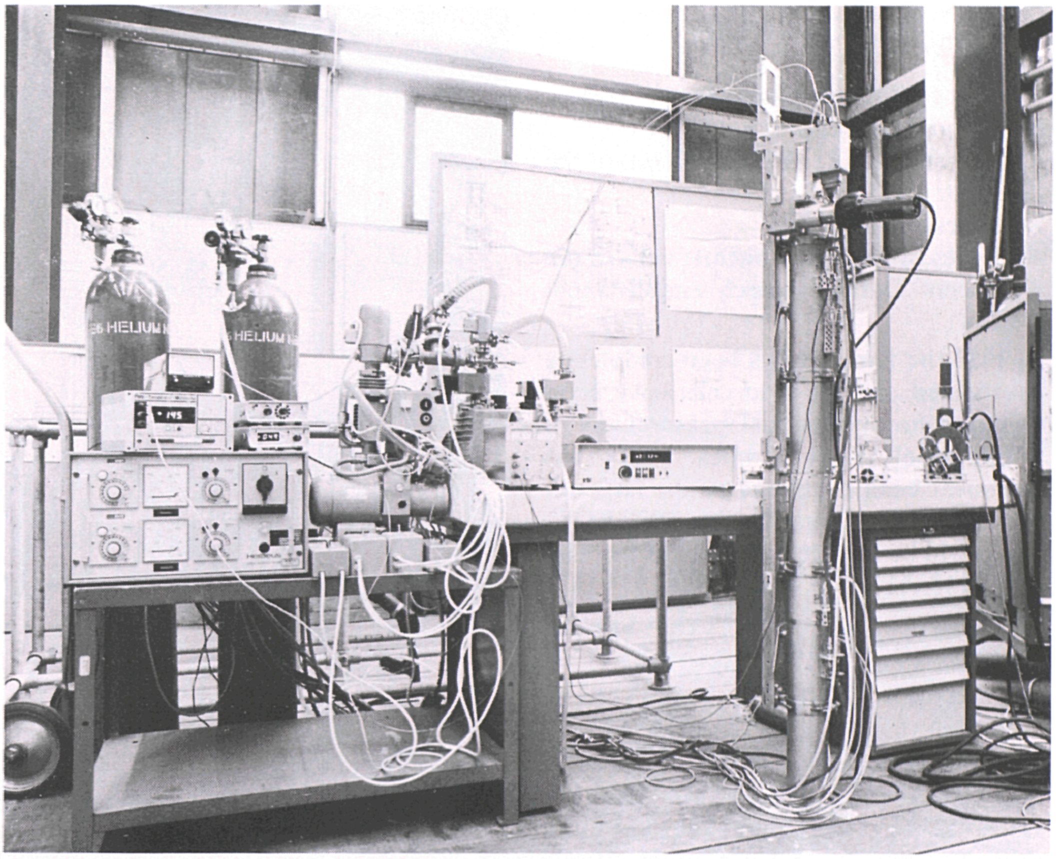
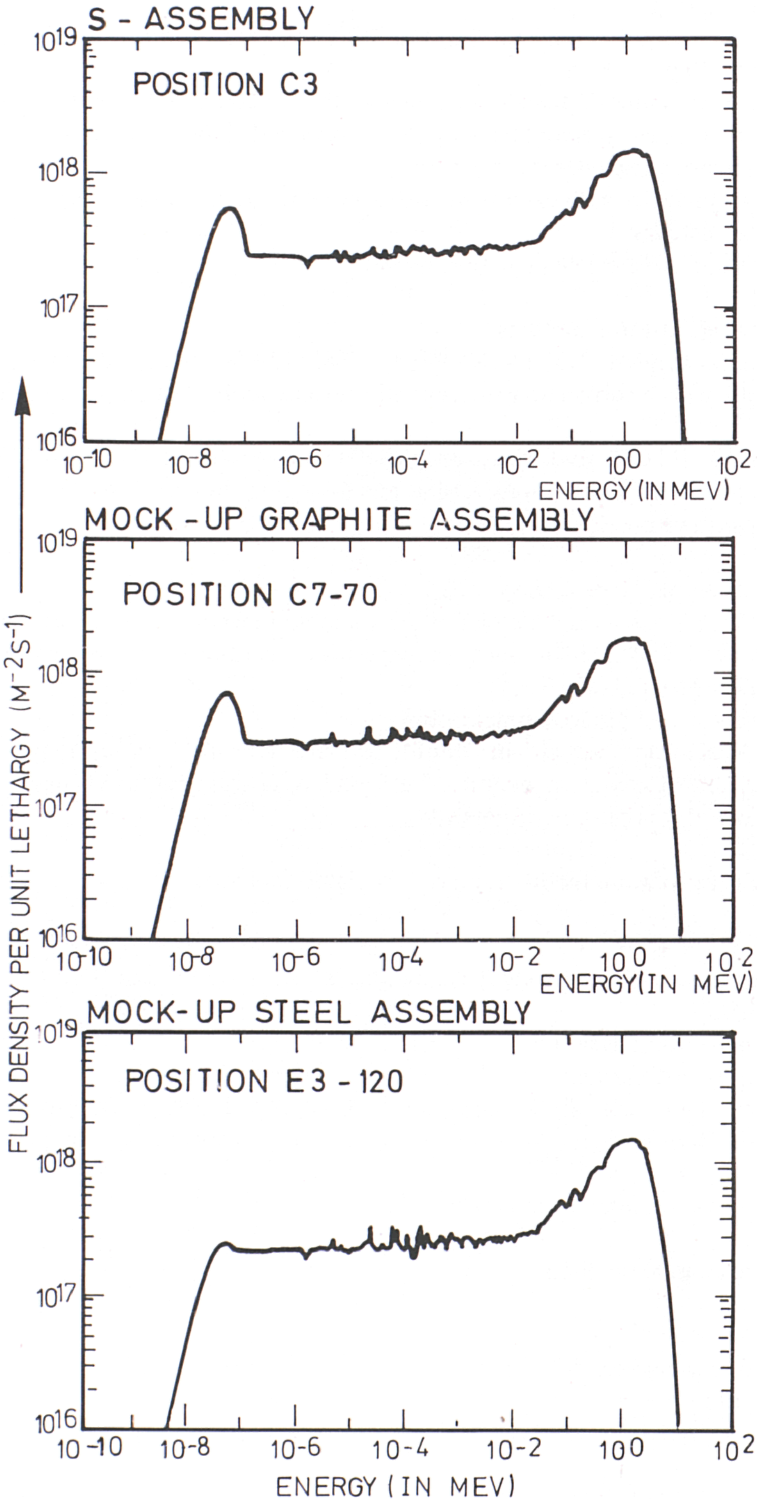


Remote encapsulation facility "EUROS"
Laboratory set-up for sodium filling and welding tests

than the simple S-assemblies, used previously. The average thermal and fast neutron fluence rate in the mock-up graphite and steel assemblies show a more pronounced change of the fluence rate than follows from computer calculations.

3.1.4 Irradiation facilities

Users of the reactor find a number of basic services and facilities which are made available to them on a routine basis and which help to cut down on development time and cost.
Most of the 1982 work consisted in routine maintenance of control equipment and stockpiling of standard in-pile capsules. New developments have been limited to those required by the forthcoming vessel replacement, in particular for the new pool side irradiation facilities, a fast pneumatic rabbit, and revised radioisotope capsules.
Two new transient test devices have been successfully taken into operation during the year, for LWR fuel ("POTRA") and LMFBR fuel ("TOP"). Both use BF_3 gas as a variable neutron absorber.



Some characteristic neutron spectra measured in mock-up assemblies (FLUX-81)

HFR Petten

Standard irradiation facilities

1. Non-fissile materials testing
Graphite, stressed or unstressed, metal or graphite/He environment Ø/6...20 mm; 300 ...1200°C Specimen recycling.
Steel, unstressed, Na environment, tensile specimens, Ø/6...12mm, 550....650°C also: non-cylindrical (Charpy, CT, etc.). Short term facilities (reloadable during reactor operation).
Low temperature Al specimen capsules (various sizes)
Graphite and steel creep facilities with on-line measure ment or specimen recycling
In-core instrumentation test rigs
Under development: Fatigue and crack growth capsules.

2. Fissile materials testing, in-tank facilities
Single or triple, double-walled Na (NaK)-filled, 500...1000°C clad temperature, 400....1200Wcm^{-1}. Optional: Neutron screen, central thermocouple, fission gas pressure transducer,....
Single or double-walled HTGR fuel rigs, graphite/He environment, 100....1000Wcm^{-1}, 800...1500°C fuel temperature. Continuous fission gas sweeping and analysis.
BF_3 operated power transient facility

3. Fissile materials testing, pool side facility (PSF)
Single-walled Boiling Water Fuel Capsule (BWFC), variable power, 70...150 bar water pressure, 200...800Wcm^{-1}, 250...350°C clad temperature. Continuous fission product monitoring. Pre-irradiated fuel pins.
Optional: Different types of fuel pin instrumentation
Double-walled, Na (NaK)-filled, single or double carrier capsule. Variable power, 500...1200Wcm^{-1}, 400...800°C clad temperature. Fuel pin length up to 500 or 1600 mm.
Optional: Different types of fuel pin instrumentation
Profilometer capsules
Under development: Encapsulation facility for pre-irradiated fuel pins

4. Miscellaneous
Different radioisotope production rigs, mostly reloadable during reactor operation
Gamma irradiation facility
Neutron activation analysis installation
Two neutron radiography installations
Beam tube nuclear and solid state physics equipment: Several diffractometers and spectrometers, mirror and filter systems, with ancillary cryogenic equipment and process computers
Under development: Pool side gamma scan facility

5. Standard out-of-pile control facilities
Gas mixing and control panels
Cooling water control circuits
Micro-processor based data loggers
Data processing computer
In-pool diameter measurement, eddy current check, neutron radiography, gamma scan facilities
Multi-purpose hot cell facilities on site

3.2 Utilization

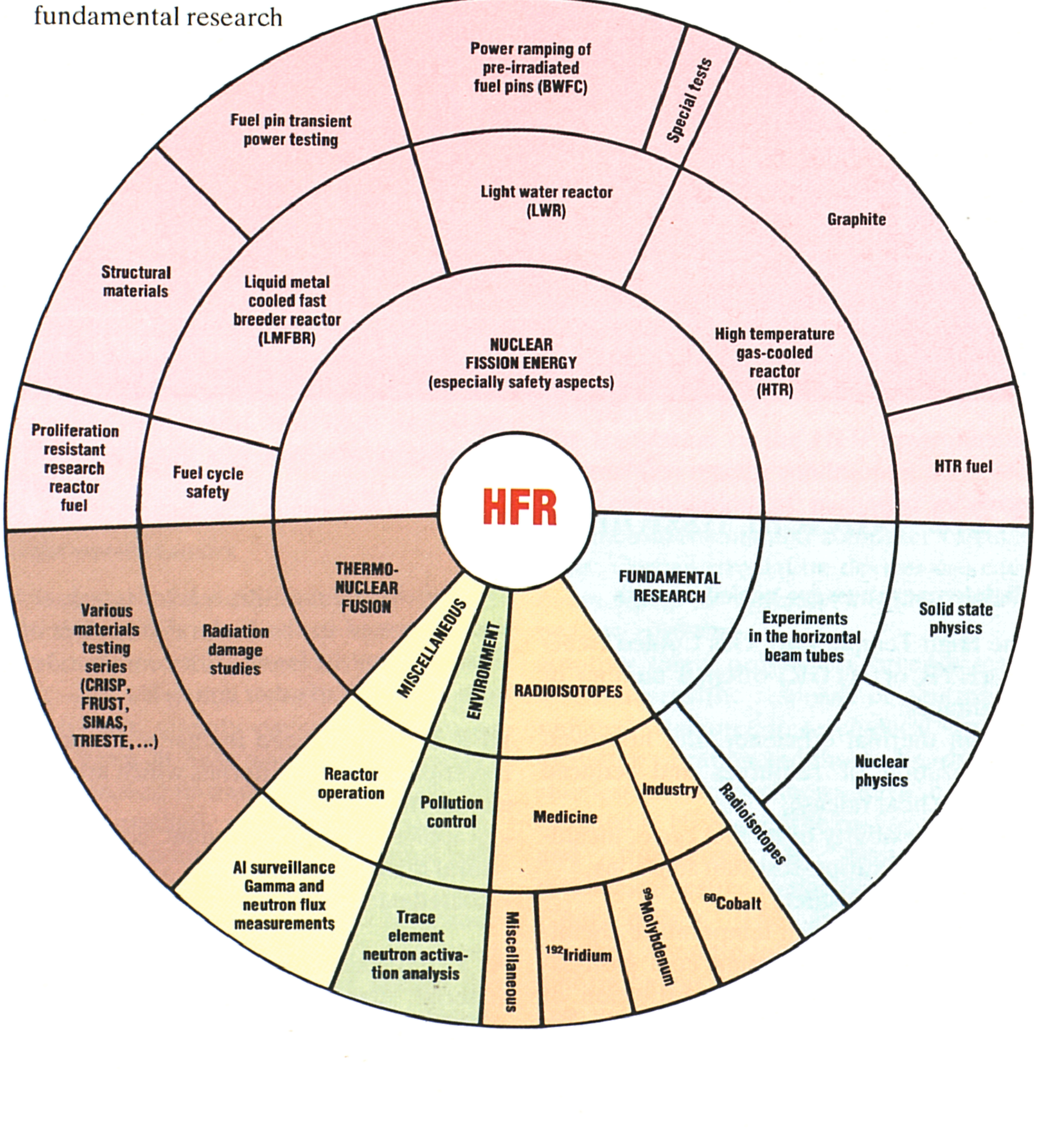
3.2.1 Scope

The experimental work carried out in HFR Petten originates from intense collaboration with teams from different research areas

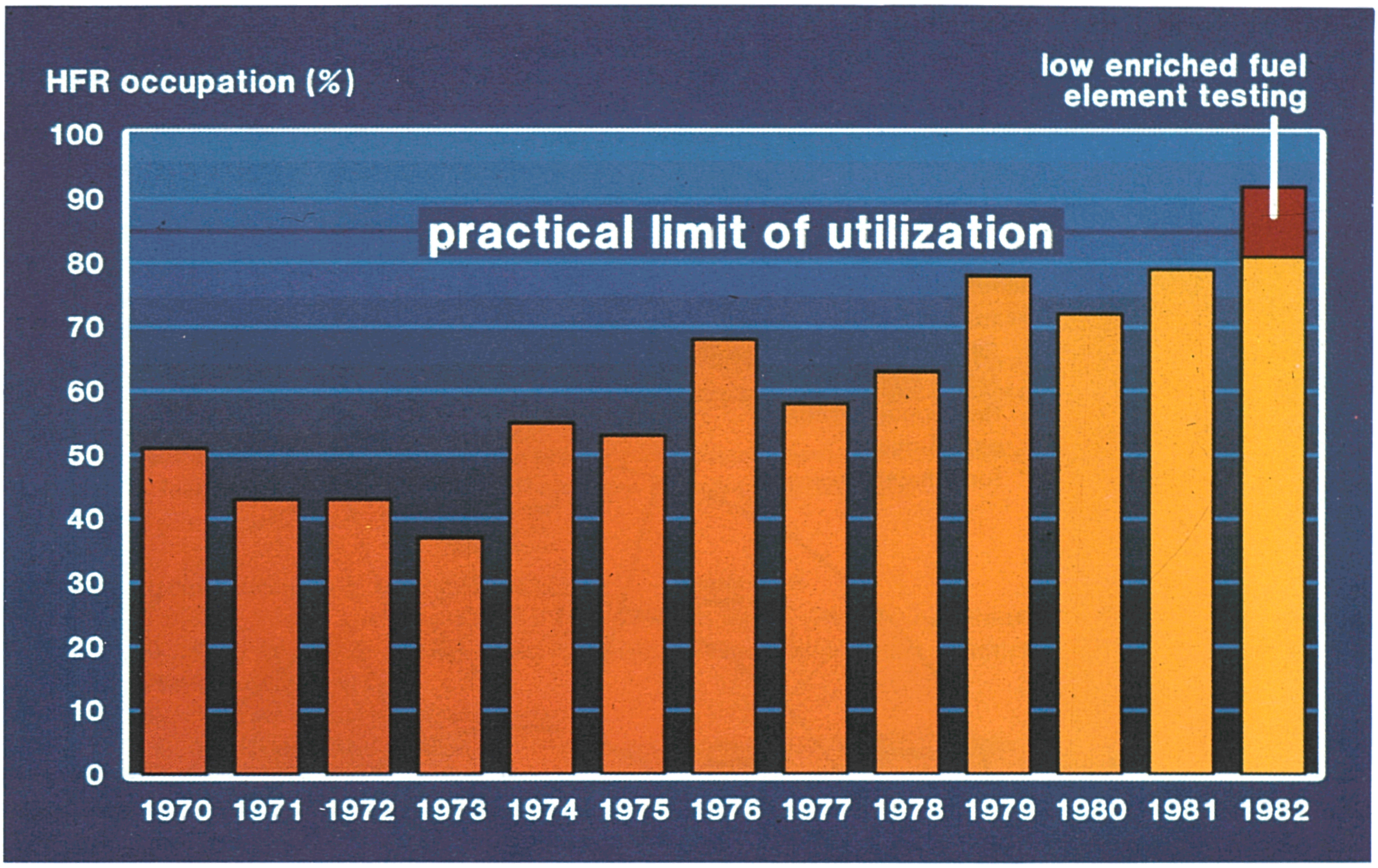
- nuclear fission energy, especially under safety aspects
- thermonuclear fusion
- environment
- fundamental research

radioisotope production for scientific, industrial, and medical applications.

1982 has been the year of another record occupation of the reactor with 81% + 11% of low enrichment fuel element testing. Several irradiation projects had to be delayed by the lack of reactor space.



HFR PETTEN
1982/83 Utilization scheme



Reactor occupation based upon irradiation units

3.2.2 Nuclear fission energy

High temperature gas-cooled reactor

The High Temperature Gas Cooled Reactor (HTR or HTGR) offers a number of advantages:

1. high thermal efficiency, i.e. improved utilization of resources and reduced waste heat release,
2. large flexibility of its fuel cycle, including proliferation-resistant solutions,
3. high inherent safety,
4. utilization for high temperature chemical processes, including coal gasification and liquefaction (substitution of natural gas and oil).

The development of this reactor type is actively pursued in the Federal Republic of Germany and in Japan with contributions from a number of other countries.

HFR Petten has been in charge of test irradiations for two materials which are typical for the HTR:

- graphite as a predominant core structural material
- coated particle fuel elements.

As a contribution to HTR core structural material irradiation testing, a large number of graphite samples has been ir-

radiated since 1962. The HFR graphite irradiation programme supplies the necessary design base for future HTR types, starting with the steam generating plant, but including the nuclear process heat and the direct cycle concepts.
The irradiation capsules contain unstressed samples (fundamental properties programme) or creep specimens under tension or compression. They are irradiated in three to four fluence steps, with intermediate measurement of their changed physical properties. For the reflector graphite material, irradiation temperatures range between 300^{0}C and 1150^{0}C, up to extreme neutron fluences.
In terms of number of irradiated samples and neutron fluences this is the most significant graphite research work in the world.
Six graphite irradiations have been terminated in 1982, and two new ones started.
Coated particle fuel element testing is performed in HFR Petten on reference coated fuel particle systems and production fuel elements for the UO_2 low enriched uranium (LEU) fuel cycle.
Two new in-pile tests have been started in 1982 which will run until the middle of 1983.

Light water reactors

A large part of the experiments carried out in HFR Petten concerns the behaviour of nuclear reactor core materials under transient and abnormal conditions.Fuel pins which have already operated for two or three years in light water power reactors are submitted to transients in specially developed irradiation capsules in order to test their resistance against abnormal conditions (overpower).
The accurate knowledge of this behaviour allows large power reactors to be operated with a maximum of assurance against the release of radioactivity (fission products).

The HFR BWFC (Boiling Water Fuel Capsule) experimental programme features 25 to 30 experiments per year, including their non-destructive tests before and after irradiation.
Work in 1982 consisted of the complete test cycle on 35 pre-irradiated fuel pins which is above the average number of previous years. A new development for a loss-of-cooling capsule has been started.
A short-term irradiation of pressure vessel steel specimens for flux level effect evaluation took place early in the year.

Liquid metal cooled fast breeder reactors

Internationally several R&D programmes are pursued with the goal of qualifying
- advanced LMFBR fuel (carbide) under normal and abnormal conditions
- mixed oxide fuel under start-up and in-situ operational transients
- structural materials.

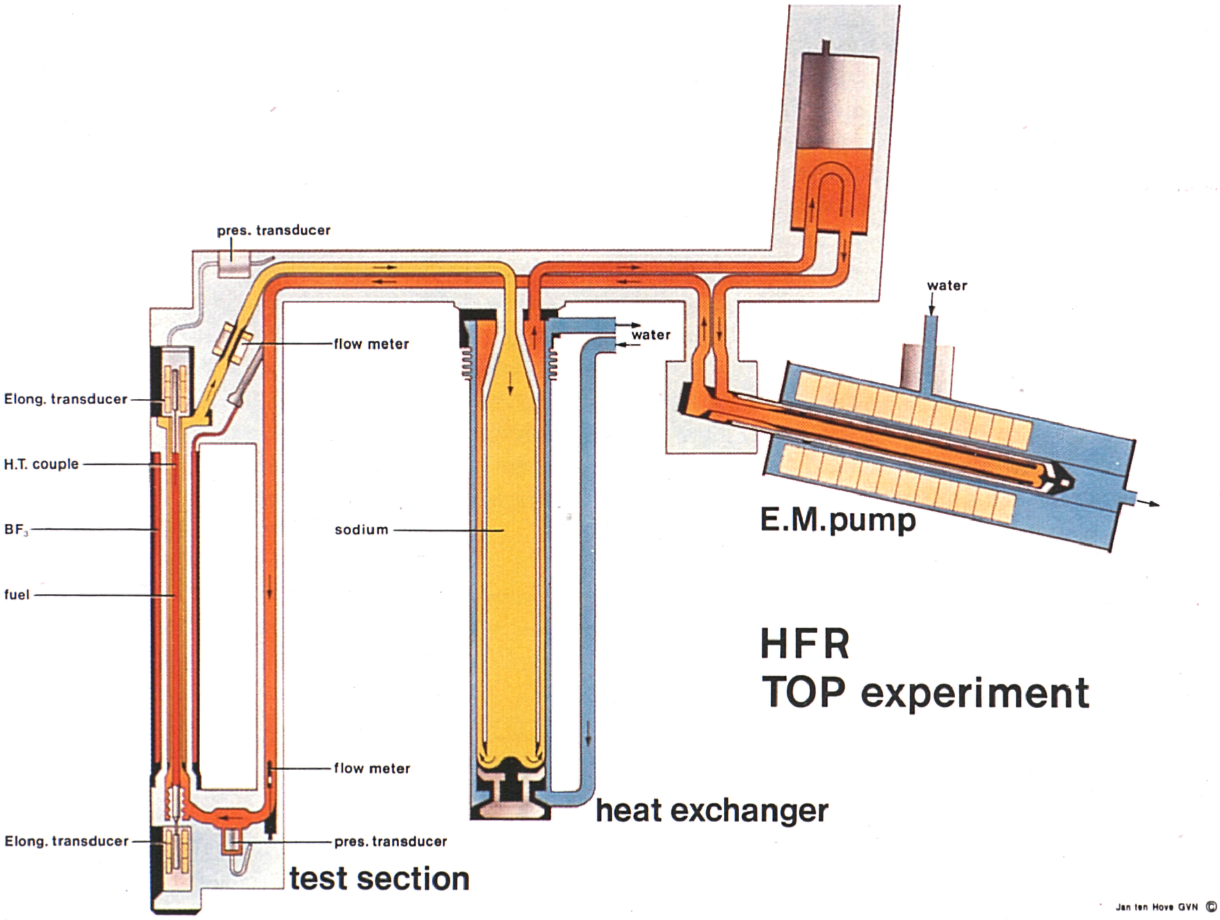
In 1982, 15 fuel pins have been submitted to "mild" power variations whereas 2 pins were tested under a sharp overpower transient (TOP test).
The translation of the HFR environment into real fast reactor conditions is achieved by a combination of particular neutron flux measurements and computer calculations. Certain irradiation devices use cadmium filters to simulate the fast reactor neutron spectrum.
Another safety problem in breeder reactors concerns the response of neutron-irradiated structures to mechanical stresses including vibration and shock. Nearly 1500 stainless steel specimens have been irradiated in HFR over the past seven years, and transferred to post-irradiation mechanical testing in shielded laboratories ("hot cells"). The irradiations have supplied accurate information of material embrittlement by helium formation and fast neutron displacements. The present

trend goes to fracture mechanics experiments and in-pile creep studies.

Development of Proliferation - Proof Research and Test Reactor Fuel (Project "LOUISE")

One of the recommendations of Working Group 8C of the International Nuclear Fuel Cycle Evaluation (INFCE) concerns the fuel of research and test reactors: wherever technically and economically feasible these reactors should be converted from the presently used highly enriched uranium to proliferation - proof reduced enriched material.
Studies on such novel fuel elements have been carried out at HFR Petten since 1977. As a contribution to the technological development, an element has been developed and designed for irradiation testing of research reactor fuel with 20% enrichment. This project managed by ECN, is covered by a large international collaboration involving the Argonne National Laboratory, USA; CERCA, Romans, France; NUKEM, Hanau, Germany; and the International Atomic Energy Agency, Vienna, Austria.
First full power test irradiations of two low enriched fuel elements which were subjected before irradiation to various measurements, tests and inspections, have been carried out in November 1981. Four test elements have being irradiated and inspected during 1982.
Together with non-destructive and destructive post-irradiation analyses, they will provide the necessary technological basis for the future conversion of low and medium power research reactors (up to 5...10MW) to proliferation-resistant fuel.

Low enriched research and test reactor fuel development.
Two full scale elements after irradiation to full bum-up.



HFR PETTEN
TOP experiment

3.2.3. Thermonuclear fusion

Fusion together with fast fission breeders and solar energy are considered to be the potential new primary sources, able to solve the problem of energy supply in the next century. For this reason a large effort is being devoted in the world and, in particular, in Europe, to the research related to the controlled thermonuclear systems.

During the past several years there have been notable developments in this field. The physics of confinement and heating of plasmas has been investigated in a number of different systems which have been developed parallel.

As confidence on the potential of plasma systems to get conditions for ignition grows, more attention is paid to the steps forward to the achievement of commercial fusion power reactors and the related technological problems, which are amongst other things materials problems.

Work in HFR Petten is embraced by the 1982/86 European Fusion Technology Programme, an implementing agreement sponsored by the International Energy Agency, and the Fusion Technology Programme of JRC Ispra.

The first irradiations have been started in 1982 and several experiments are under development or manufacture (see table).

Supporting studies on neutronic aspects of fusion material irradiations in HFR and on the required metrology (dosimetry) have been initiated.

SURVEY OF FUSION MATERIALS IRRADIATION TESTS IN HFR PETTEN

Project Name	Specimen Material	Test Type	Status
SINAS	Austenitic stainless steel	Post-irradiation tensile and creep tests Post-irradiation crack growth experiment	Under irradiation
FRUST	Austenitic stainless steel	Post-irradiation tensile	Under irradiation
	Austenitic stainless steel, incl. AMCR	Post-irradiation tensile	In manufacture Irradiations in 1983 and 1984
CRISP TRIESTE	Austenitic stainless steel	In-pile creep measurements	Under assembly. Irradiation start 1983 and 1984
LOCFIRE FATMAC and others	Austenitic stainless steel	In-pile fatigue In-pile crack growth	Under development. Irradiation in 1984/86
SUPRA	V_3 Si	Fundamental research on radiation damage in superconducting materials	Under assembly. Irradiation in 1983
VABONA	V - 5Ti	Radiation damage studies	
	Cu, W, ceramics	Radiation damage studies	Under development. Irradiation in 1985/87
	Li_{17} Pb_{83}	Breeding and tritium permeation studies	

3.2.4 Protection of the environment

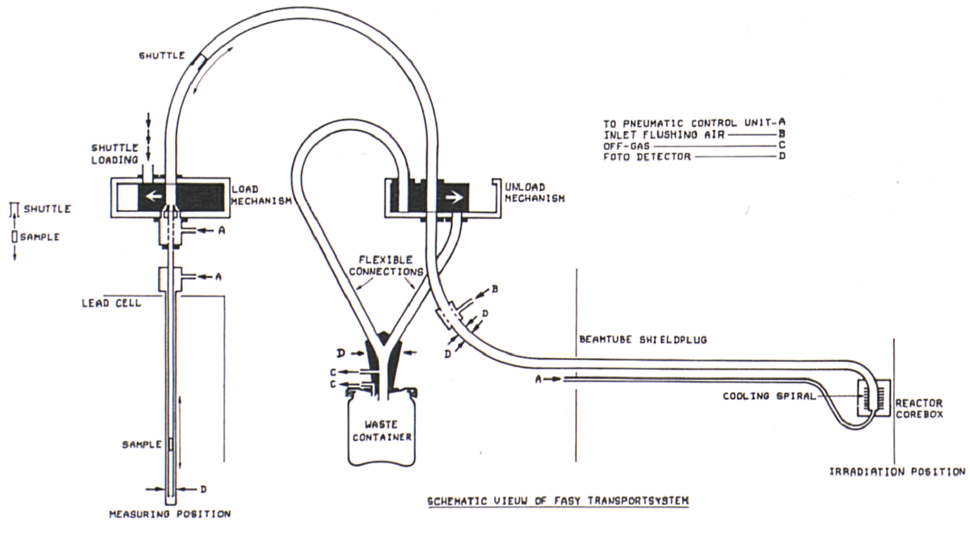
Neutron activation analysis is a very efficient and accurate method for the determination of a large number of trace impurities and contaminants, like arsenic, mercury, cadmium, uranium etc. Therefore it is a method, which can be used as an effective instrument for environment pollution control, e.g. for the determination of arsenic, selenium and antimony in residues from coal-firing by means of a sensitive radiochemical procedure, which has been developed recently.
In the field of activation analysis HFR Petten offers several facilities over a wide range of irradiation times and sample volumes, using both conventional and prompt gamma ray techniques.

In 1982 three new irradiation facilities for neutron activation came into operation:

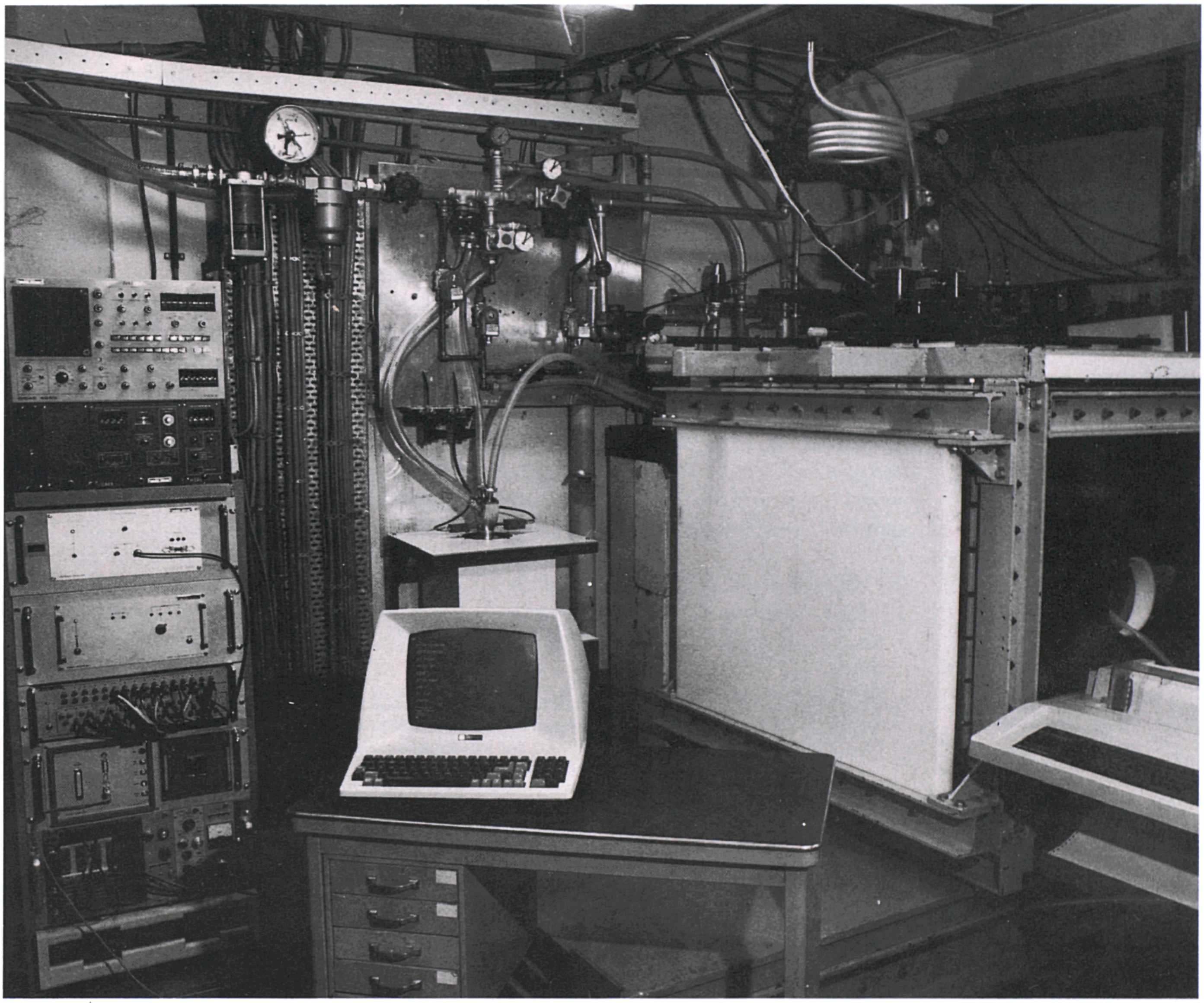
- the epithermal low-flux facility in the pool
- the fast rabbit system FASY in HB-10
- the prompt capture gamma ray facility in HB-4.

Apart from that, the routine system for INAA based on irradiations in the low flux rotating PROF was developed further.

The main problem in the routine use of the epithermal facility, the (relative) flux measurement per aliquot, was solved by extending the use made of the standard annular iron flux monitor.
The fast rabbit system FASY makes it possible to realize return-times down to 0.1 s while shuttle and capsule are separated during return. This system has been applied to the determination of selenium in about 100 mg aliquots of biological material based on the reaction $^{76}Se\ (n,\gamma)\ ^{77m}Se$, $T\frac{1}{2}=18$ s, down to concentrations of about 10 $ng.g^{-1}$.
The prompt capture gamma ray facility is equipped with a sample changer for 20 aliquots, packed in teflon capsules. A 50 cm^3 coaxial Ge(Li) crystal is used as detector. Typical counting times are around 10^4s except for boron where 10^3s is usually sufficient.The array is applied to silicates, in particular to fly-ash, for the determination of boron and some other traces as well as for the major constituents.



Protection of the environment
Fast rabbit system FASY for neutron activation analysis



FASY
Receiving and counting station

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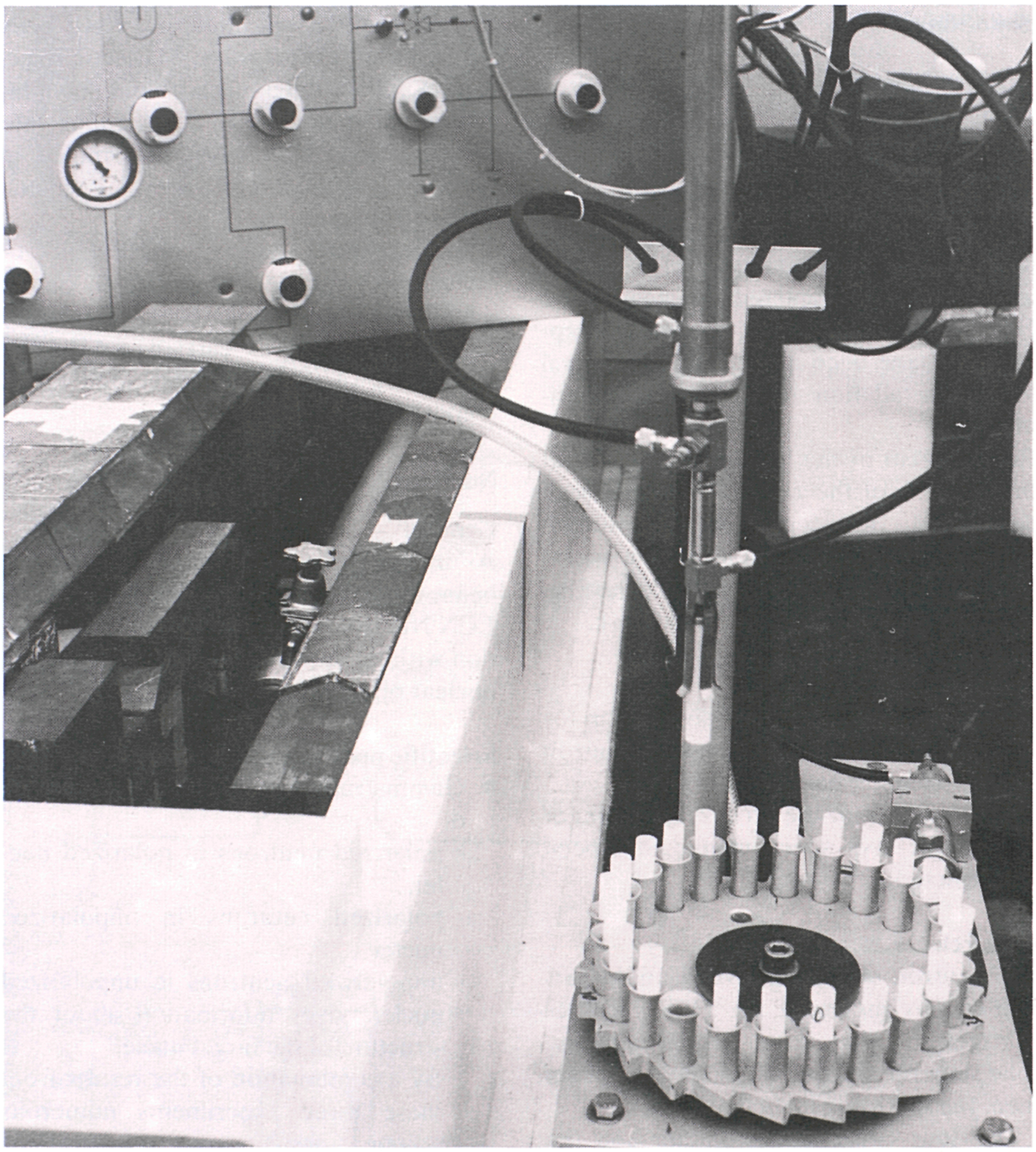

Prompt γ-ray facility at beam tube HB 4

3.2.5 Fundamental research

Certain interactions of neutrons with matter, like prompt gamma emission after neutron capture, scattering, diffraction, etc., can be used for studies of fine structures of nuclei or crystal structures of solids. The installations around the reactor use "beams" of neutrons extracted from the core through horizontal tubes. Spectrometers arranged around the target area measure intensity, energy orientation and polarization of the emitted radiation, which are then analysed by means of computer codes.

Solid state physics

The five experimental facilities for neutron scattering research have been in continuous operation. Again the research programme was carried out in close relation and contact with Dutch Universities in such a way that a number of joint projects could be completed. In view of the HFR vessel replacement operation preparations have been made for the removal and re-installation of the beam experiments.
Replacement of the beryllium reflector at the eastside of the reactor core has been considered. In order to obtain optimum parameters for such a modification an experiment has been designed for a test reflector in the R2-O reactor at Studsvik.

Instrumental

- A high resolution collimation system for the multi detector of the powder neutron diffractometer has been installed.
- Programmes for the process computer of the triple- axis spectrometer have been completed.

Research

The neutron scattering investigations carried out by means of the HFR facilities comprised topics from crystallography, solid state physics and metal physics. From them the following main items:

- The four circle diffractometer and the powder dif fractometer were used for several crystallographic and magnetic structure determinations and the ana lysis of deformation texture in metals and alloys.
- The polarized neutron diffractometer has been used for the further study of spin density distribution in 3d metal alloys. The systematics in the analysis of such experiments could be improved significantly.
- Antiferromagnetic materials have been studied in several ways. Magnetic structures, phase diagrams with unknown intermediate phases and transitions into such phases have been determined in systems with widely varying magnetic anisotropies.
- An extensive study of the kinetics of clustering and decomposition in binary and tenary alloys has been completed. Further work was carried out in the structure of metallic glasses and liquid alloys.

Nuclear physics

General

As in the previous years four horizontal beam tubes have been used by the FOM-ECN Nuclear Structure Group in cooperation with university laboratories and other nuclear research centres.

Scientific programme.

- Gamma radiation emitted after capture of
  - polarized neutrons in polarized nuclei,
  - polarized neutrons in unpolarized nuclei,
  - unpolarized neutrons in unpolarized nuclei, gives information about the structure of the target nuclei.

  By a combination of the results from these three experiments numerous unique assignments of nuclear parameters have been made for the isotopes ^{24}Na, ^{46}Sc, ^{48}Ti and $^{64,65}Cu$.

- Measurements of the performance of an ($n\alpha$) detector for the $^{10}B(n\alpha)$ 7Li reaction (to study parity interference) have been initiated. This reaction has also been studied with polarized neutrons and polarized ^{10}B nuclei to obtain information about the mixture of the spin channels involved in the reaction.

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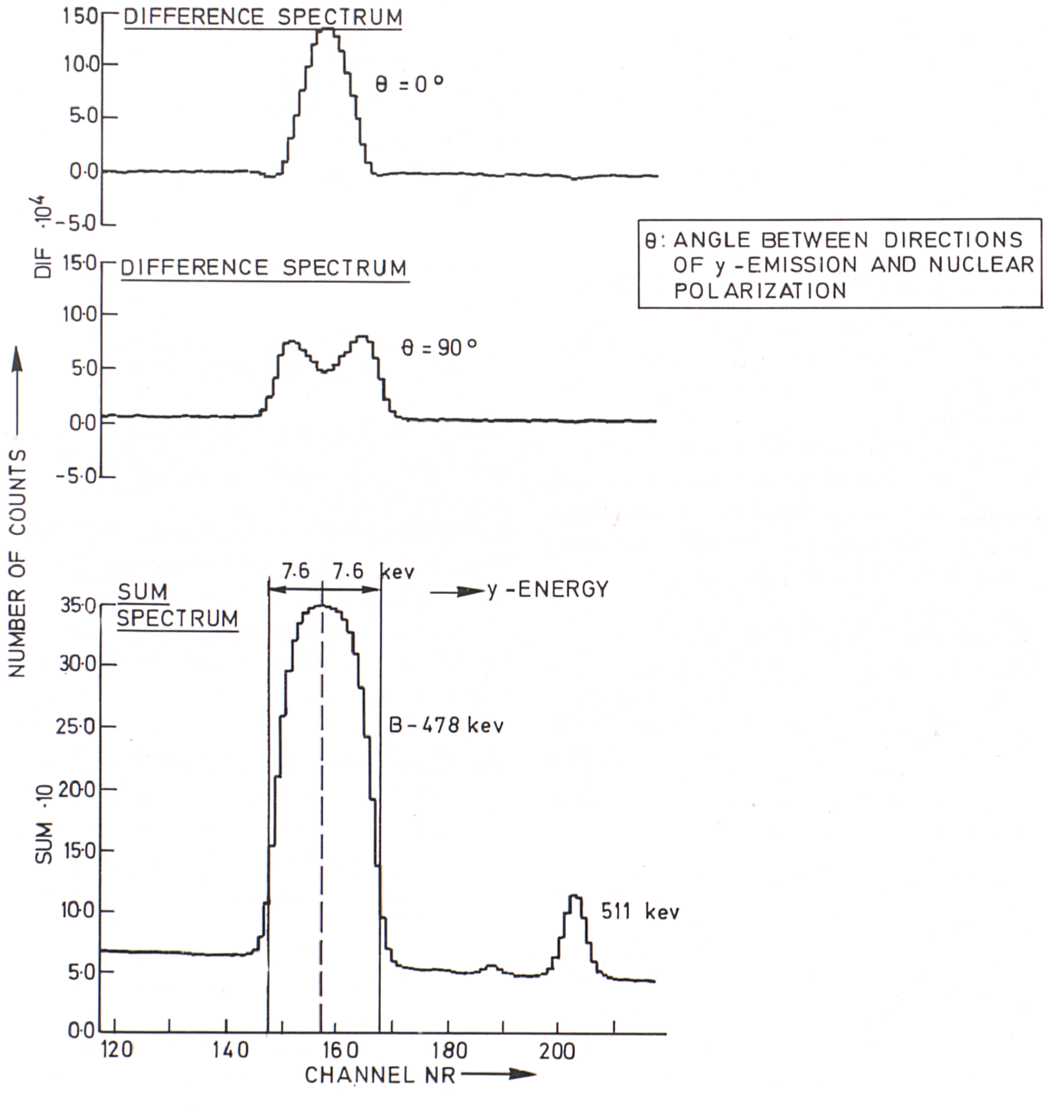
been initiated. This reaction has also been studied with polarized neutrons and polarized ^{10}B nuclei to obtain information about the mixture of the spin channels involved in the reaction.

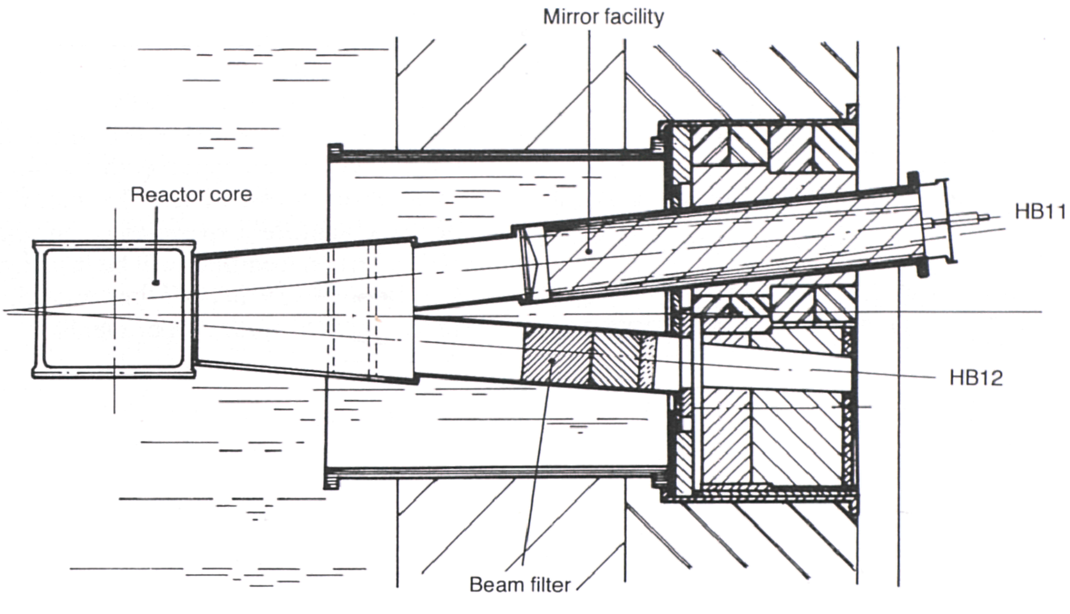
- Study of the distribution of the γ-strength.
- Description of the nuclear level densities.

Experimental.

- An (n,α) detector to study parity interference has been installed at the longitudinal polarized neutron beam.
- In the frame of the HFR vessel replacement a design has been made of a twin beam facility to replace the former thermal column. The HB11 part of the new facility will be equipped with the present nickel mirror system for thermal neutron capture experiments. In the HB12 part an iron filter will be installed to yield a 24 keV neutron beam facility for resonance capture experiments.



Results from measurements of γ-radiation after capture of polarized neutrons in polarized ^{10}B nuclei.
From the presence of the double hump in the -spectrum for $\theta = 90^0$ and the absence for $\theta = 0^0$ one can conclude that the α- and Li-particles from the $^{10}B(n,\alpha)^7Li$ reaction are emitted in a direction perpendicular to the orientation axis.



Twin-beam construction to replace the former thermal column

3.2.6 Radioisotopes

Radioisotopes are produced in HFR Petten in a variety of multi-purpose or dedicated facilities.
The 1982 production showed an incrase of 35% with respect to previous years, although the total number of individual targets showed a slight decrease (1981:2380, 1982:1907 targets).

Radioisotopes for Medical Applications
Diagnosis and therapy of cancer have made increasingly use of a short-lived radioisotope called "Technetium 99 m" (^{99m}Tc) which can be produced in high purity by radioactive decay of another short-lived radioisotope, viz. "Molybdenum 99" (^{99}Mo).
^{99}Mo is produced in HFR Petten by two different techniques:

1. irradiation of molybdenum (activation route)
2. irradiation of highly enriched uranium (fission product route).

The production of ^{99}Mo in HFR Petten has been increased in 1982 to fulfil the growing demand.
Presently up to three transports with ^{99}Mo leave Petten every week, according to an exact time table.
Most of the other isotopes produced in the HFR (e.g. ^{192}Ir) have been for medical applications too.

Radioisotopes for Sterilisation Plants
A large ^{60}Co capsule has been irradiated throughout 1982. At the end of the year, an average specific activity of $65^{Ci}/g$ had been reached, corresponding to a total of 56kCi ^{60}Co.

3.2.7 Miscellaneous

Several in-tank positions have been scanned for their nuclear heating values using the in-pile gamma calorimeter.

Surveillance specimens monitoring radiation damage of the present vessel aluminium alloy were irradiated during four cycles.

4 CONCLUSIONS

HFR Petten has been operated in 1982 in fulfilment of the 1980/83 JRC Programme Decision.
Reactor operation and maintenance data have been met within a few percent of the goals set out in the annual working schedule. Reactor occupation exceeded the planned figures with a record number of experiments carried out in support of a large variety of research programmes.
The major development effort has been deployed in preparation of the 1983 reactor vessel replacement.

HFR PETTEN

Utilization. Advantages

- **Fusion reactor material studies:**
  Several proven irradiation facilities under operation Advanced neutron computation and metrology
- **Fast breeder reactor structural materials irradiations:**
  Many highly reliable irradiation capsules and special hot cell equipment available
- **Fast breeder reactor fuel pin testing under abnormal conditions and under operational transients:**
  Long-standing expertise, availability of the PSF and of special in-pile instrumentation, advanced control equipment
- **Light water reactor fuel pin power ramping:**
  Availability of the PSF and large control equipment
- **High temperature gas cooled reactor graphite and fuel element irradiation:**
  Modern sweep loop facilities, well-known flux spectra, several proven capsule types, hot cell re-encapsulation facility for active samples
- **Nuclear structure and solid state physics experiments:**
  Numerous experimental installations, long-standing expertise
- **Radioisotope production, activation analysis:**
  Regular reactor operations, many special facilities, high neutron fluxes
- **Neutron radiography, neutron dosimetry development:**
  Modern, purposeful equipment, well-known flux spectra
- **Six computing and data acquisition/processing installations available**

HFR PETTEN

Utilization. 1982 Achievements

- **Fusion reactor materials:**
  Four new devices taken into operation

- **Fast breeder reator structural materials irradiations:**
  Irradiation and hot cell testing of 200 vessel steel specimens

- **Fast breeder reactor fuel pin testing under abnormal conditions and under operational transients:**
  17 fuel pins tested under transient conditions

- **Light water reactor fuel pin power ramping for improved operating economy and safety:**
  Power ramp tests on 35 pre-irradiated fuel pins

- **High temperature gas cooled reactor graphite and fuel element irradiations:**
  Contribution to the data base of the HTGR: 950 graphite samples under irradiation, some under stress (creep samples). Two new fuel tests started.

- **Nuclear structure and solid state physics experiments:**
  Continuous utilization of eight horizontal beam tubes. Improvements on several experimental set-ups.

- **Radioisotope production, activation analysis:**
  1900 samples and capsules irradiated for medical and industrial applications, environmental pollution control, research purposes

- **Neutron radiography, neutron dosimetry development:**
  280 neutron radiographs taken.contributions to HFR flux level and spectra knowledge, and to international dosimetry work

- **Non-proliferation:**
  Contributions to the development of reduced enrichment fuel for research reactors

5 HFR Publications 1982

1. P. Blanchard, H. Scheurer
Irradiation Technology of Unstressed Graphite Samples in the HFR Petten
Atomenergie-Kerntechnik, Bd. 40, Nr. 3 (April 1982)
(Art. 24.688)

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Lecture at: Fast, Thermal and Fusion Reactor Experiments Conference, Salt Lake City, 12-15 April 1982
(ORA 30.467)

3. R. Conrad
Irradiation Device for HTR Fuel Testing under Abnormal Thermal Conditions
Atomenergie-Kerntechnik, Bd. 40, Nr.3 (April 1982)
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4. Th. v.d. Kaa, D. Vader, P. Zeisser
Facilities for the LMFBR Steel Irradiations in the Petten High Flux Reactor
Lecture at: Fast, Thermal and Fusion Reactor Experiments Conference, Salt Lake City, 12-15 April 1982
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5. D.W. Klage, R. Conrad
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Atomenergie-Kerntechnik, Bd. 40, Nr.3 (April 1982)
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Int. Symp. on Applications and Technology of Ionizing Radiations Riyadh, Saudi Arabia, 12 March 1982
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10. P. von der Hardt
Operation of the High Flux Reactor Programme Progress Report, July-Dec. 1981
COM 3930

11. P. von der Hardt
Survey of European LWR Fuel Irradiation Test Facilities
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12-15 April 1982

14. HFR Division
Neutron Radiography at the HFR Petten
EUR 7915 EN FS

15. P. von der Hardt
Annual Status Report: Operation of the High Flux Reactor
EUR 7931 EN

16. P. Zeisser, F. Mason
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Neutron radiography Proceedings of the First World Conference, San Diego, California, USA, December 7-10, 1981
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Irradiation facility for remperature transient and cycling experiments of HTR fuel elements
Lecture at: International Topical Meeting on Irradiation Technology Grenoble, 28 September - 1 October 1982
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Irradiation performance of advanced coated particles for high temperature gas cooled reactor fuel cycles
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23. M. Leipold, J. Markgraf, D. Perry
LWR fuel rod testing facility in HFR Petten
Lecture at: International Topical Meeting on Irradiation Technology Grenoble, 28 September - 1 October 1982
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High Flux Reactor Programme Progress Report, January 1982
COM 4002

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